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He does not state whether there is any difference in elevation or in character of soil at the corners of this triangle; but, if there is none, then this observed difference of motion is highly interesting and important, and should be tested and verified in every possible way by interchange of instruments, resetting of supports, etc., in order to be sure in every way that there is no local peculiarity of instrument or method of attachment to the soil. Doubtless this will have been fully attended to in Professor Milne's continuation of these interesting experiments.

H. M. PAUL.

A RECENT DISCUSSION OF THE AXIOMS OF MECHANICS.

THE logic of the physical sciences will always remain a fascinating field for the philosophic inquirer, and doubtless also for the special student of those sciences. The recent efforts towards a 'reform in logic' in Germany have not left this field untouched; and one of the first in importance, among the books that bear on the general topic, is the work whose title is given below. The author has qualified himself for the task by a lengthy study of the history of the development of his science, and he has the power to suggest much more than he directly says. In short, we have here a man who combines definiteness with depth of thought; and his book, whether useful or not to the specialists in mechanics, is surely very suggestive to the student of logic.

The author represents in his way the new empiricism of Germany, — a doctrine that has grown up out of a study of Kant and the English philosophy combined, and that as certainly points back again into the realm of specially philosophic discussion as it appears anxious to be forever beyond that realm. This new empiricism is much more suggestive than the older empiricism of J. S. Mill. He had founded all inductive interpretation of nature on the causal principle, and the causal principle itself again on an inductive interpretation of nature. The new empiricism escapes from this circle by assuming a relatively *a priori* principle in all induction, but seeks to remain empiricism still by making this principle no abstract axiom, but a sort of ultimate form or tendency of intelligence, viz., the tendency to conceive of the facts of experience in the most economical way. This interest in economy of thought shall, in the new empiricism, take the place of the old axiom of causality, and, in fact, of all the mysterious axioms of past logicians. This tendency to economy is to be

the true *a priori* that Kant sought. It is to give us no knowledge transcending experience, but only a necessary presupposition concerning experience. What for bare experience would seem a confused mass, becomes for the scientific thinker, by virtue of this tendency to economy, a world of law. All the laws are indeed statements of empirical fact; but the statements never could assume this form save by virtue of the effort to economize thought.

Such is the general statement of the new empiricism. Our author, for the most part, confines his use of it to his special task, and lets general philosophy as much as possible alone. Yet he cannot but constantly suggest to the reader the philosophic problems peculiar to his method. For the rest, he lays claim in the preface to considerable relative originality in the development of his own doctrine. Before Kirchhoff and Helmholtz applied to mechanical science the general theories of the new empiricism, Mach had outlined his views in a published essay. He is thus entitled to individual credit, and open to separate criticism.

Applied to mechanical science, the new empiricism, as our author and Kirchhoff have expressed it, takes the form of declaring the purpose of mechanics to be, "the simplest possible description of the motions that are in the world." Thus at a stroke the science is to be freed from all mysterious elements. Those old ideas of force, of inertia, and the rest, are to be defined afresh in such a way as to conform to this logical theory. The science is to have its two perfectly plain bases; viz., experience of motion, of velocity, of direction, etc., and the effort to think this experience with the least effort and the greatest unity.

The historical form that Mach gives to his doctrine makes it especially attractive and enlightening; and we hope for much good effect from this element in the book. Mechanical science, as Mach frequently repeats, had its origin very plainly in the need of men whose handiwork, owing to its technical complexity, was difficult to describe to those new in the craft. The learner must be enabled to see the permanent elements of the experience of his craft beneath, and in all their endlessly various applications; he must be brought to an 'übersichtliche erfassung der thatsachen:' hence the need of quite general and simple descriptions, applying to fundamentally important facts. Economy of description thus from the first becomes the artistic principle, as it were, of this technical instruction.

If this is the origin and general method of the science in its embryonic stage, the origin

Die mechanik in ihrer entwicklung historisch-kritisch dargestellt. Von E. MACH, professor an der Universität zu Prag. Leipzig, Brockhaus, 1883. 10+483 p., illustr. 8^o.

of the use of axioms appears, according to our author, in the fact that the learner, from long habit (not, as Mach thinks, from any *a priori* insight), has come to expect instinctively, and so to conceive very economically, certain simple sequences of facts. Purely for economic reasons, and not on philosophic grounds, nor for that matter with any philosophic justification, the teacher is disposed to seize upon these elementary facts as the constituents into which more complex facts can be analyzed, and by which these cases can be easily described. These simpler sequences are chosen simply because the learner already knows of them, and can more readily grasp them. When one calls them *a priori*, one forgets how easily a puzzling question can confuse us about their meaning, and even about their truth. Their self-evidence is the self-evidence of instinct, and they are in no philosophical sense *a priori*.

After the foregoing summary, we may fairly assert that in one respect, at any rate, Mach's method is praiseworthy; and that is, in its tendency to get rid of the mysterious element of his science. Whatever one may hold about the *a priori* in general, there is no doubt that we have had enough and too much of the purely mystical *a priori*. If there is any fundamental rational truth at the bottom of science, if science is more than a mere aggregation of facts, this rational basis, when we come to state it, must be as frank and honest and manly a principle as the most commonplace adherent of the empirical philosophy could desire. The old-fashioned *a priori*, in science, in morals, in religion, used to be represented as an arrogant and intolerant thing, mysterious in its manner of speech, violent and dogmatic in its defence of its own claims. The English empiricists used to hate this aristocratic *a priori*, and they shrewdly suspected it to be a humbug. What they gave us in its place, however, was a vague and unphilosophic doctrine of science, that you could only seem to understand, so long as you did not examine into its meaning.

Mach's view avoids the mystery of the old *a priori*. He leaves us still the mystery of the correspondence of external nature to our fundamental interests in the simplicity of its phenomena. Yet this mystery has the look of the genuine philosophic problem. The new empiricism is not and can not be final; but it promises to prove an excellent beginning, and one can at least commend it to those instructors in elementary mechanics who still puzzle their pupils with their use of the old-fashioned, mystical *a priori*. Mach's fundamental prin-

ciple of the economy of thought is one that any intelligent pupil, with a few empirical facts before him, could be got to understand. But, as many not extraordinarily stupid pupils have so often felt, the mysterious way in which such axioms as the 'principle of sufficient reason' used to appear, aimlessly wandering to and fro in the text-books, could not but perplex, without in any wise helping, the young mind. That even to-day, when the empirical methods in elementary mechanics are so well developed and so generally used, the 'principle of sufficient reason' is occasionally called in to help teachers and text-books out of difficult places,—this fact is surely a 'sufficient reason' in itself for a careful study of such books as Mach's. There are many teachers of elementary mechanics to-day, who, while abhorring metaphysics, and constantly glorifying experience, never know or can tell just what ought to be done with that 'principle of sufficient reason,' which, however, as it used to be applied when it held sway in elementary mechanics, was the most miserably 'metaphysical' of all confused statements. The most ardent believer in the rational *a priori* must therefore delight to find, in such a book as Mach's, the foundation laid for future philosophic inquiry in the clear and sensible empiricism of the author, tentative and transient though this doctrine itself may prove. Only when the vague and mystical have been banished from the mere terms and axioms of the science, can a philosophic student hope successfully to grapple with the question, "How is empirical science, with certain and fixed results, possible at all?" Every one is therefore interested in such undertakings as our author's, whether one is student of mechanics or of logic, or teacher of either; for every one is interested in plain and frank thinking, free from appeals to merely mystical principles.

In concluding, we must call special attention to our author's discussion of the question of absolute and relative motion, which he seems to us to have treated with marvellous skill; and thus we are obliged unwillingly to leave a book that is so full of learning and suggestion.

THE SNAKE-DANCE OF THE MOQUIS.

CAPT. BOURKE has given us here a most interesting account of his experience among the

The snake-dance of the Moquis of Arizona; being a narrative of a journey from Santa Fé, New Mexico, to the villages of the Moqui Indians of Arizona, with a description of the manners and customs of this peculiar people, and especially of the revolting religious rite, the snake-dance. By JOHN G. BOURKE, captain third U.S. cavalry. New York, Charles Scribner's sons, 1884. 371 p., 31 pl. 8°.